Environmental Hazards and Risk Assessment and Management
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CATÁLOGO DE EVENTOS HIDRO-GEOMORFOLÓGICOS EM PORTUGAL CONTINENTAL (1865-2015)

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https://www.sciencedirect.com/science/article/pii/S0309170818304056

1. OBJECTIVES

This work has the following objectives:

(1) to characterize the hydro-geomorphological disaster events documented in the DISASTER database for the period 1865-2015;

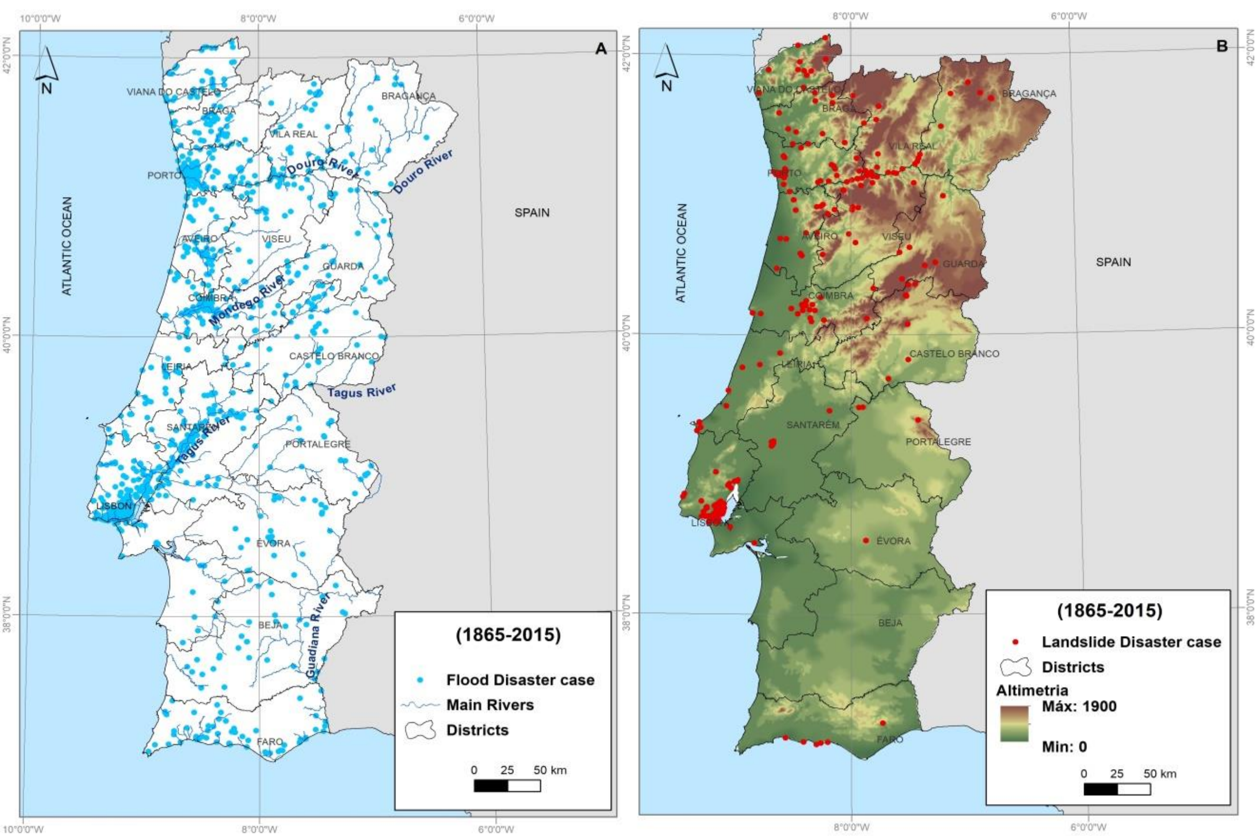
(2) to classify and analyse the main atmospheric circulation characteristics by means of weather types associated with the disaster events, including possible presence of Atmospheric Rivers;

(3) to present a national disaster events catalogue and to discuss the role of rainfall as main driving force of hydro-geomorphological disasters in Portugal.

(4) To present disaster events with impacts in the Iberia Peninsula.

2. DATA AND METHODS

2.1 Disaster database and Disaster events



Flood Disaster cases (a) and landslide Disaster cases (b) (1865-2015).

Disaster database register those floods and landslides that, independently of the number of affected people, caused casualties, injuries, evacuated or homeless people (Zêzere et al., 2014).

Disaster case as a unique hydro-geomorphologic occurrence (flood or landslide), which fulfils the DISASTER database criteria and is related to a unique spatial location and a specific period of time (Zêzere et al., 2014).

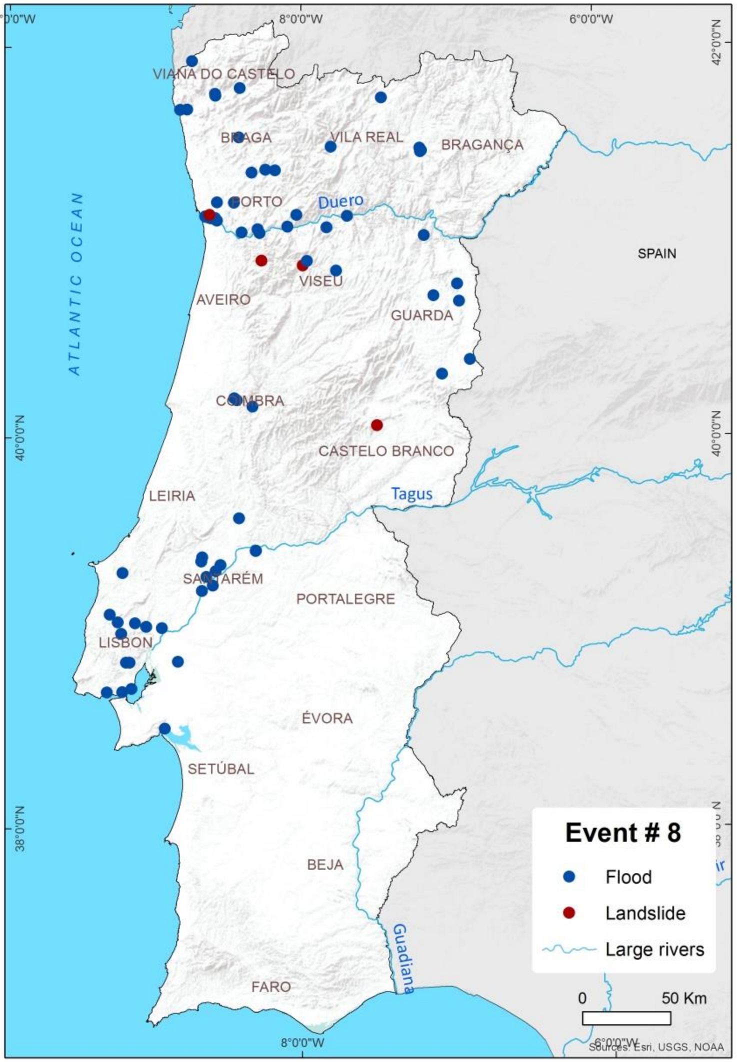
2.1 Disaster database and Disaster events

Disaster cases are grouped into a set of discrete **Disaster events** that share the same trigger mechanism and a specific magnitude in time. Disaster events were selected respecting the following criteria:

i) the disaster event should include at least 3 disaster cases;

ii) in temporal terms a disaster event ends when 3 consecutive days without recorded disaster cases are found; and

iii) in spatial terms disaster events must be located within a relatively continuous spatial pattern devoid of isolated disaster cases.



Total 130 disaster events

2.2 Reanalysis dataset

1) 20th Century Reanalysis (20CR) version 2c (Compo et al., 2011) (NOAA/ERSL PSD) with a resolution of 2º by 2º latitude longitude grid between 1865 and 2014. This dataset provides a continuous 3-D description of many meteorological fields from 1851 to 2014 and was already used successfully in others works (Pereira et al., 2016; Trigo et al., 2014).

2) We have converted the 3-hourly precipitation rate at surface to **daily accumulated precipitation** in order to have an approximation of the precipitation landfall at the Iberia Peninsula (IP) domain. The precipitation output from the reanalysis precipitation is not the optimal solution; however, it provides a consistent precipitation data that could be comparable for the entire centennial period.

3) Using 6 grid points from the 20CR that are located over Portugal the daily mean accumulated precipitation was obtained for each day since 1865 till 2015. The daily cumulative precipitation for Portugal was computed for **each climatological year**, for the period 1865-2015.

4) The long term climatological year accumulated precipitation **10th, 50th, 90th and 95th percentile** was also computed for the period 1865-2015, highlighting the Disaster events and the days with Atmospheric Rivers.

2.4 Circulation weather types

The atmospheric circulation conditions are determined using physical or geometrical parameters associated to the direction, velocity and vorticity of the geostrophic flow based on 16 SLP grid points (Trigo and DaCamara, 2000) retrieved from the 20CR.

The daily CWTs were computed with the 16 grid points centred in Portugal, for the 1865–2015 period using the same method as Trigo and DaCamara (2000) an adapted version of the Lamb weather type).

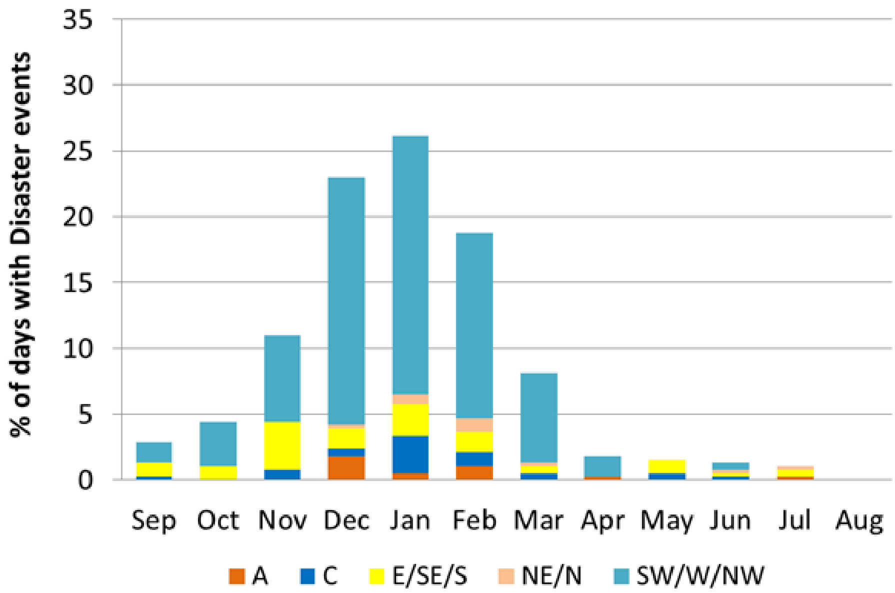
26 different weather types were defined and further re-ordered into 10 types where the 18 hybrid (8 for each C or A hybrid) CWT are assigned to their corresponding directional CWT (Ludwig et al., 2016; Rebelo et al., 2018).

2.4 Circulation weather types

Most of the precipitation in Portugal is produced by Cyclonic (C) and westerly component (SW/W/NW) CWT's.

E, SE and S CWT's can also produce some precipitation in Portugal especially in the south since they are usually associated to cut off low systems and convective processes (Ramos et al., 2014a).

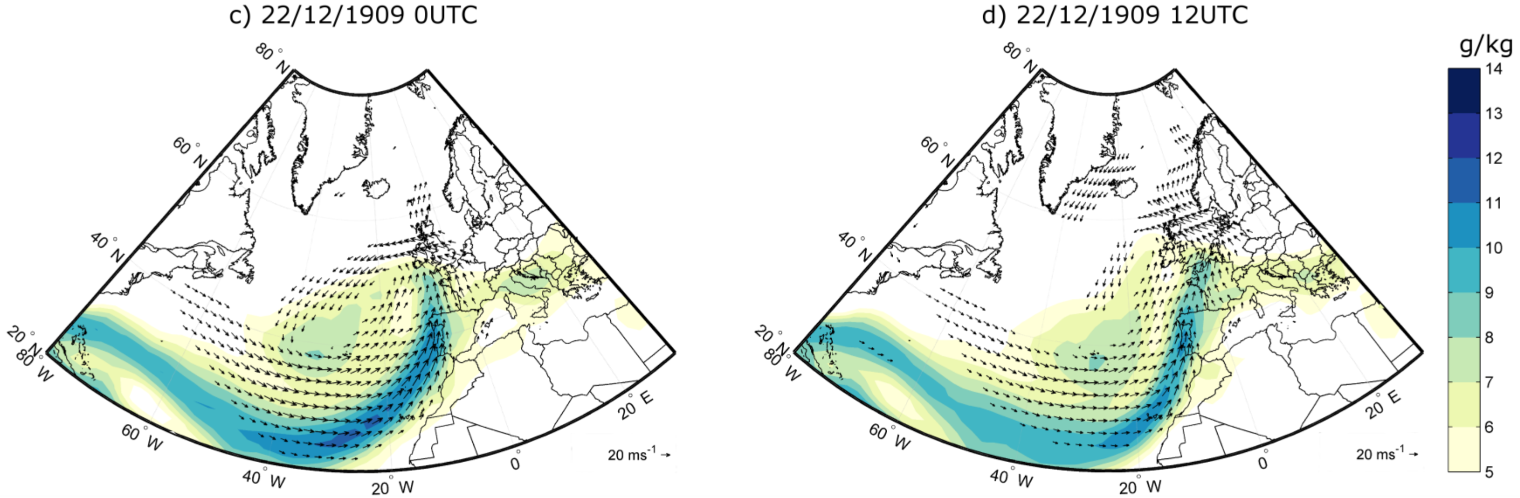
Anticyclonic (A) and northerly types (NE and N) are predominant in summer months and usually associated to dry conditions in mainland Portugal.



Percentage of days with Disaster events (1865-2015) and the corresponding CWT.

2.5 Atmospheric Rivers database

The AR detection scheme is based on the vertically integrated horizontal water vapour transport (IVT), following the same approach and domain as (Ramos et al., 2015).
The IVT was calculated at a 6-hourly time frame in the 1865-2015 period, between 1000hPa and 300hPa.



The wind vector (m/s) and specific humidity (shaded, g/kg) at 900hPa level for the 22 December 1909 at c) 00UTC and d) 12UTC. Only wind vectors with wind speeds above 12.5 m/s are shown.
(December 1909 event #8)

3. RESULTS

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3.1 Disaster events characteristics

Event ID	Event type	Date	Affected districts	Dominant CWT	AR	Nr. Days	Disaster cases	Fatalities	Injured	Evacuated people	Displaced people	Affected people
1	F; FF	25-26 Nov 1865	11	SW, W	N	2	9	**21**	0	0	0	21
2	F	14-15 Dec 1868	3, 16	W	Y	2	4	9	0	0	0	9
3	F	7-9 Dec 1876	3, 7, 14, 15	W, NE	N	3	10	8	0	0	12	20
4	F; UF	4 Nov 1891	11, 15	C	N	1	6	1	1	6	7	15
5	UF	19 Jan 1895	11	SW	N	1	4	0	0	24	0	24
6	F	12-14 Feb 1900	5, 6, 9, 14	W, A	Y	3	10	2	0	51	0	54
7	F; L	9-12 Feb 1904	1, 3, 13, 17	W, A	Y	4	4	**27**	1	1	3	32
8	F; FF; UF; L	20-28 Dec 1909	1, 3, 4, 5,6, 9,10,11,13, 14, 15,16,17,18	W, SW, A	Y	**9**	**83**	**37**	4	**679**	478	1216
9	UF	28 Nov 1910	11	W	N	1	3	0	0	9	0	11
10	F; L	8-17 Dec 1910	1, 11, 13, 14, 18	W, NW	Y	**10**	11	4	**10**	13	209	236
11	F; FF; UF; L	5-13 Feb 1912	8, 9, 11, 13, 14, 15	SW, W, NW	Y	**9**	14	17	2	22	0	43
12	F; FF	31 Jan – 1 Feb 1914	1, 6	W	N	2	4	2	6	9	11	28
13	F; UF	7 – 11 Dec 1915	13	SW, W	Y	5	3	1	**11**	3	0	15
14	UF	17 Mar 1916	11	SW	N	1	11	0	0	30	0	30
15	UF; L	20-22 Sep 1921	11	C, SE	N	3	5	6	9	23	0	38

3.1 Disaster events characteristics

	Min.	Max.	Best fit probability distribution	Kolmogorov Smirnov test	Disaster events ID with P ≤0.01	Disaster events ID with P ≤ 0.05
Disaster cases	3	83	Pearson 5	0.1319	-	8; 84;95
Days with events	1	12	Gamma	0.1454	95; 101	8; 10; 11; 28; 37; 47; 95; 101; 111
Fatalities	0	522	Generalized Pareto	0.2397	84	1; 7; 8; 38; 84; 97
Injured	0	330	Generalized Pareto	0.3088	84	10; 13; 60; 82; 84; 107
Evacuated people	0	4244	Generalized Pareto	0.0615	95	8; 32; 95; 101; 114
Displaced people	0	14322	Generalized Extreme Values	0.2368	73; 94; 95; 97	35; 59; 73; 82; 84; 88; 94; 95; 97; 101

Best fit probability distributions and disaster events with 0.01 and 0.05 probabilities according to the number of disaster cases, days with events, fatalities, and injured, evacuated and displaced people.

3. RESULTS

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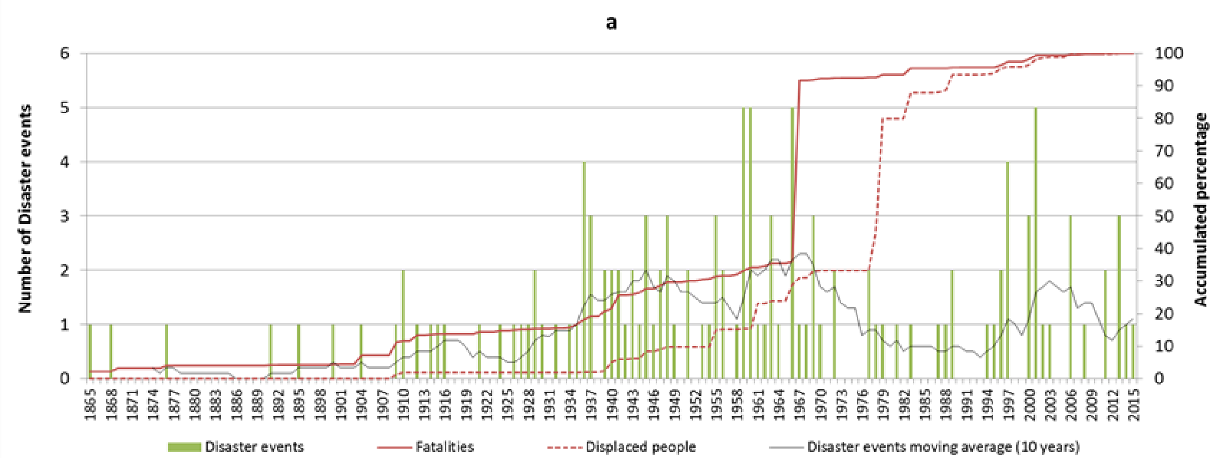
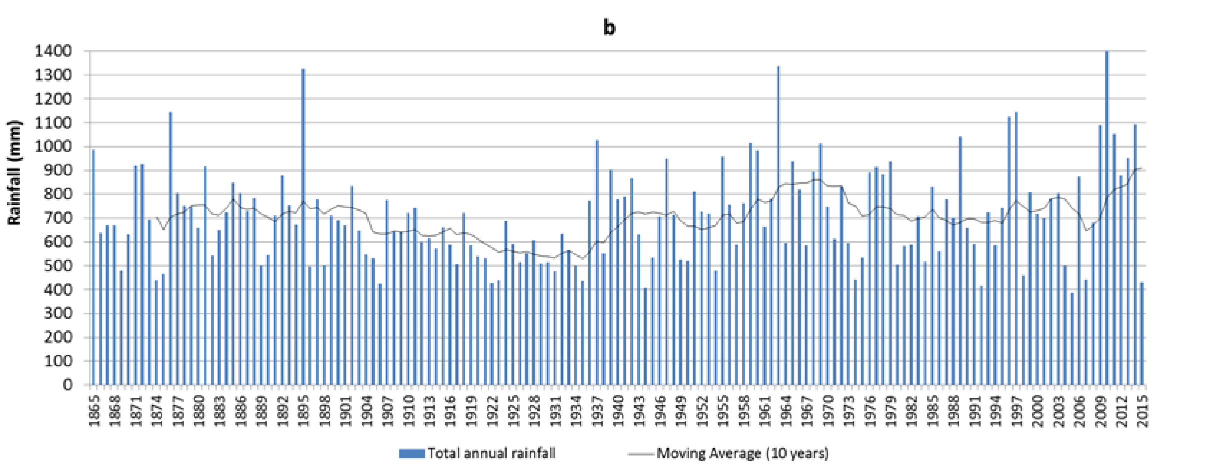
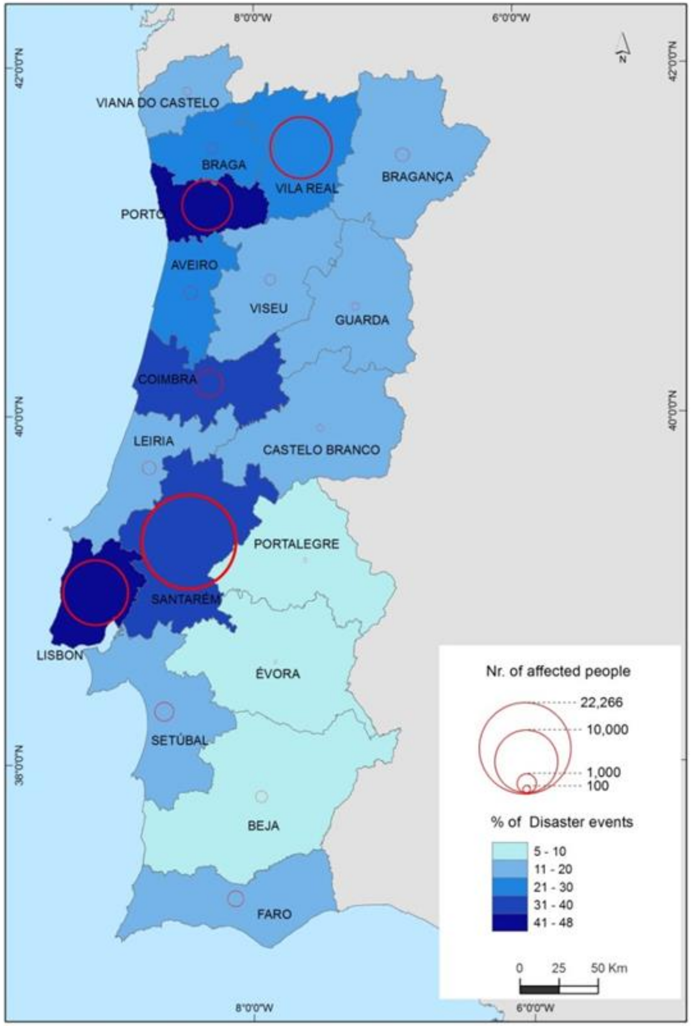
3.2 Temporal and spatial distribution of the Disaster events





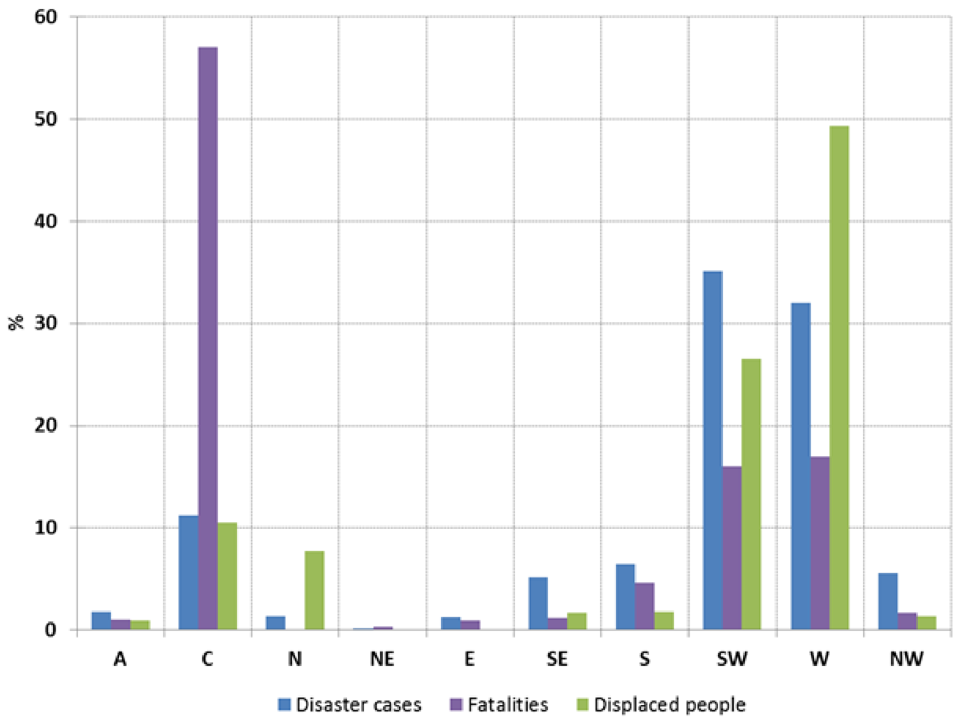
Number of Disaster events and accumulated percentage of fatalities and displaced people (a); total annual rainfall for Lisbon rain gauge (b). Decadal moving average for Disaster events and total annual rainfall is also represented.

3.2 Temporal and spatial distribution of the Disaster events



Number of affected people and percentage of Disaster events per district.

3.3 Circulation Weather types



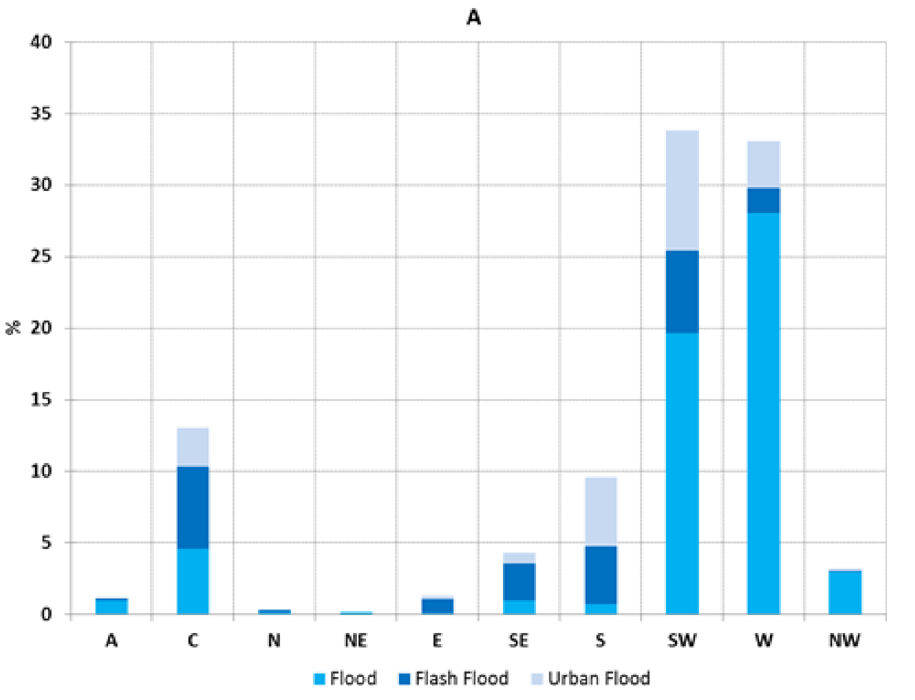
Percentage of Disaster cases, fatalities and displaced people according to the CWT of the total set of Disaster events.

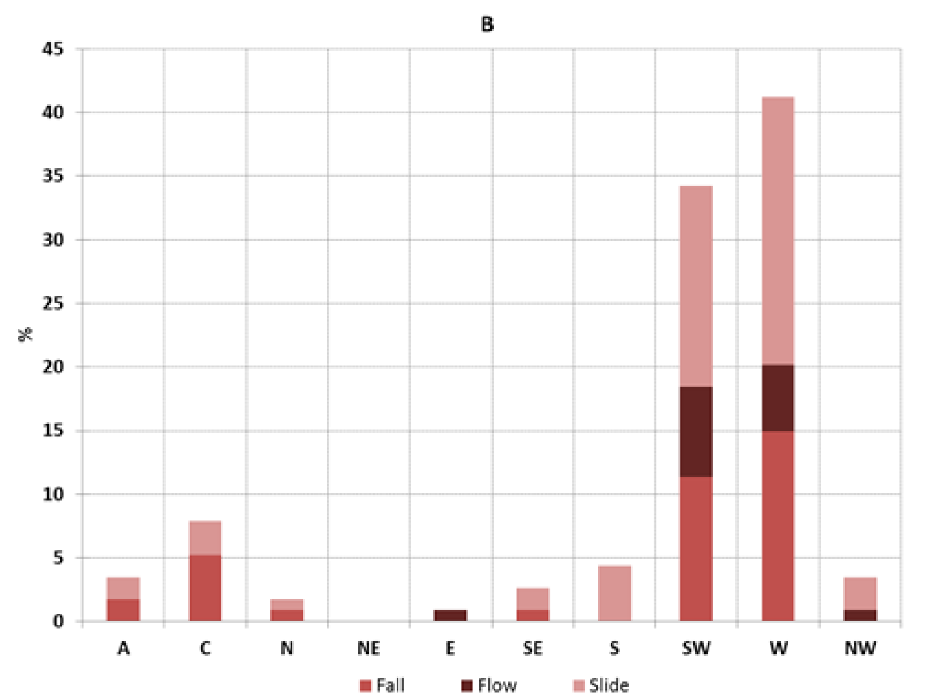
Cyclonic CWT is widely associated with convective systems that can generate flash floods and urban floods often responsible for fatalities and injured people.

CWTs with a westerly component (NW, W, SW) can be associated to prolonged wet periods that can induce flood events in the main rivers and landslides in the mountain areas.

3. RESULTS

3.3 Circulation Weather types



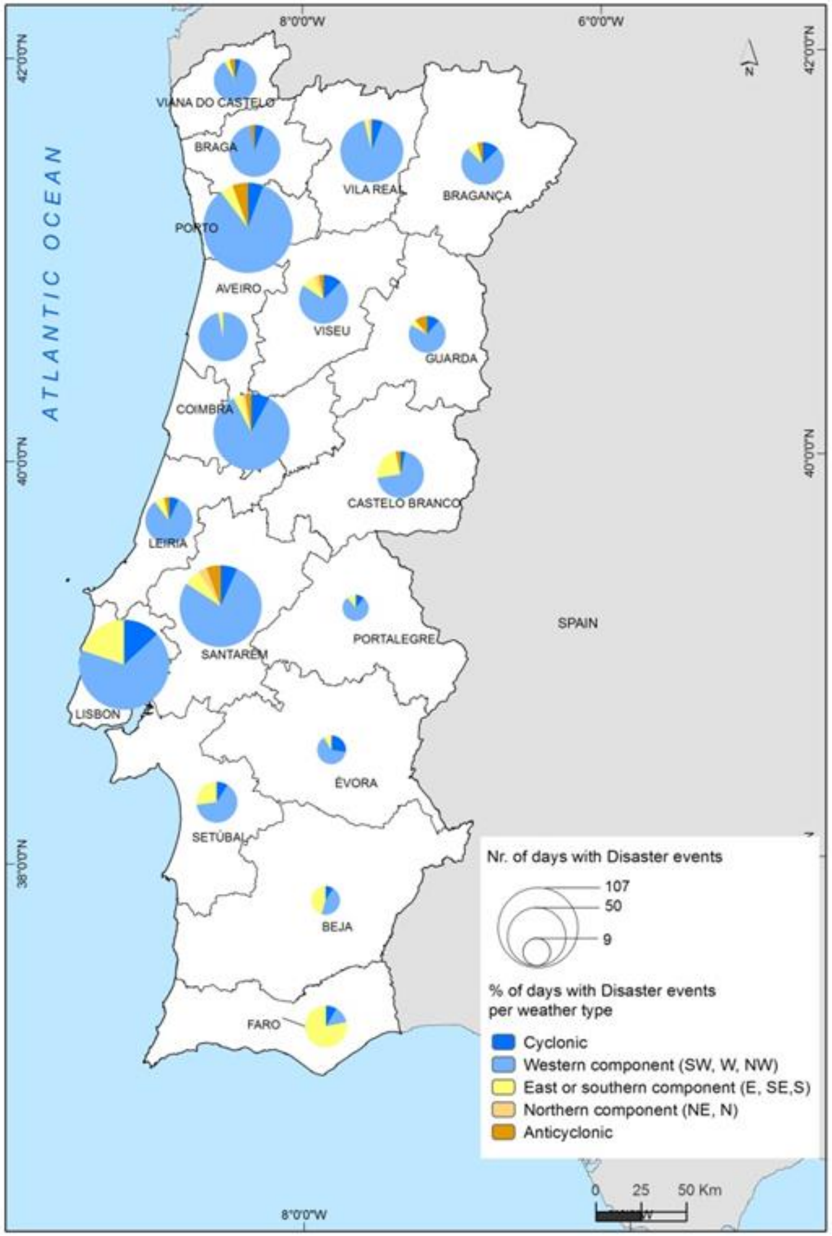


Percentage of flood types (a) and landslides types (b) identified in Disaster events, according to the CWT. The sum of the percentage of floods, flash floods and urban floods by CWT is 100% (a); the sum of the percentage of falls, flows and slides by CWT is 100% (b).

3. RESULTS

3.3 Circulation Weather types

- In the central and northern Portugal Disaster events are mainly driven by SW, W, NW and C Weather Types;
- The CWTs with a southern and eastern component (E, SE and S) are the main drivers in southern Portugal.



Number of days with Disaster events and percentage of days per CWT.

3. RESULTS

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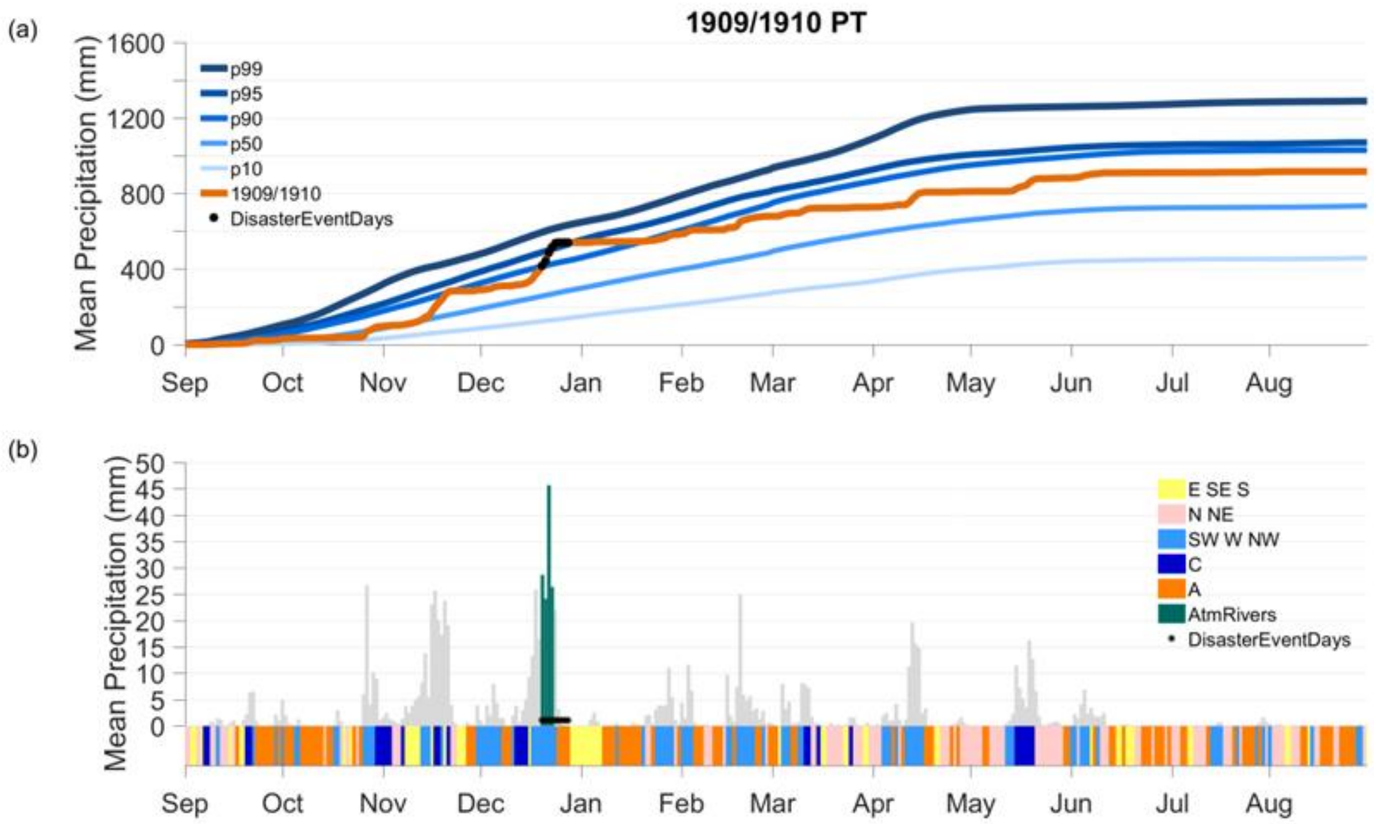
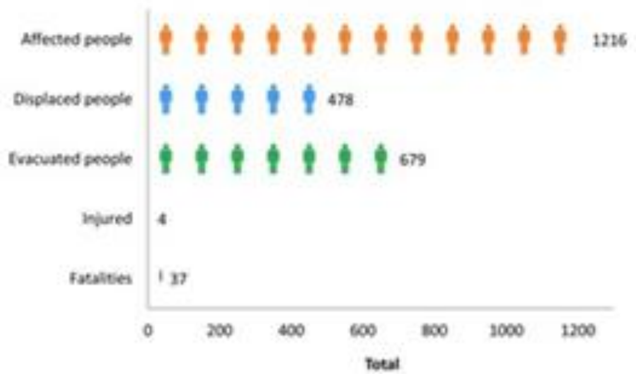
3.3 Circulation Weather types



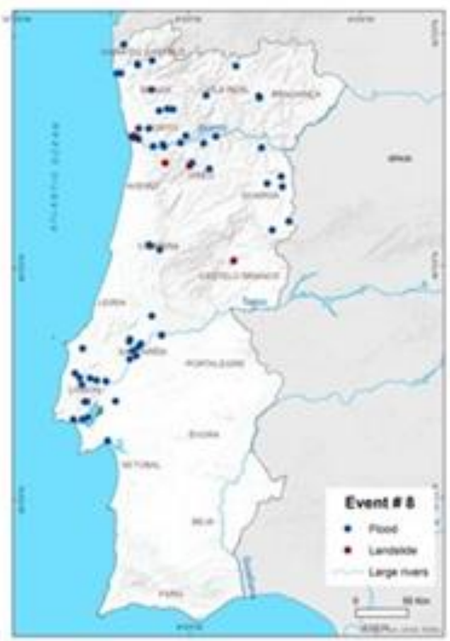
Long term climatological year accumulated rainfall 10th, 50th 90th and 95th percentile compared with the climatological year 1909/1910 (a); mean daily rainfall (light grey bars) along with the correspondent circulation weather type (in colours) (b).

20 - 28 December 1909

Human Damages



Spatial distribution

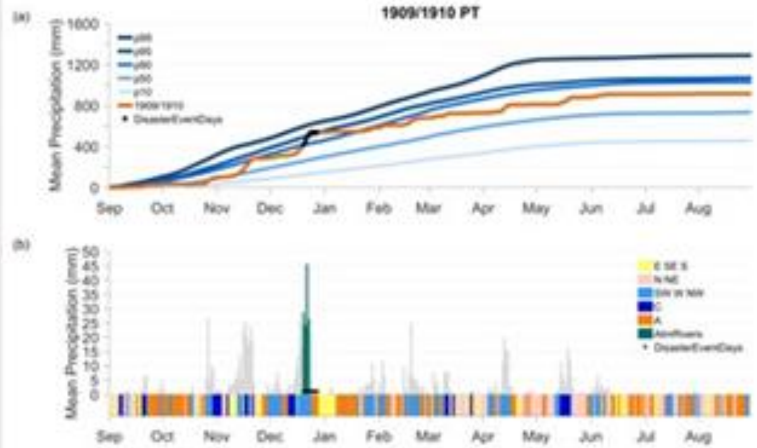


83 Disaster Cases
79 Floods
4 Landslides

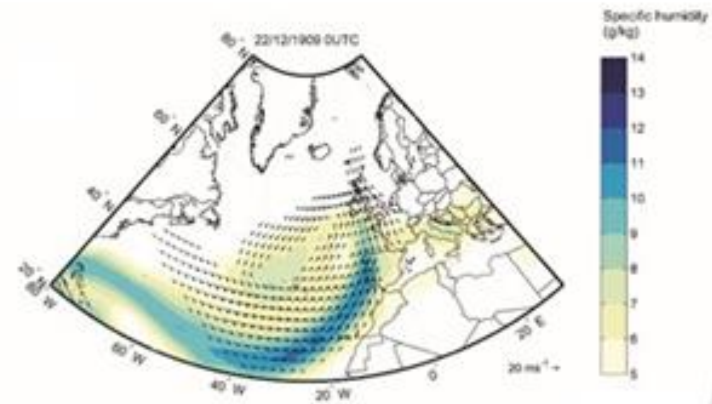
Rainfall Percentil:
At 20 Dec. 87th
At 28 Dec. 97th

Dominant CWT:
W; SW and A

Antecedent rainfall conditions



Atmospheric circulation



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Natural Hazards and Earth System Sciences
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Spatial impact and triggering conditions of the exceptional hydro-geomorphological event of December 1909 in Iberia

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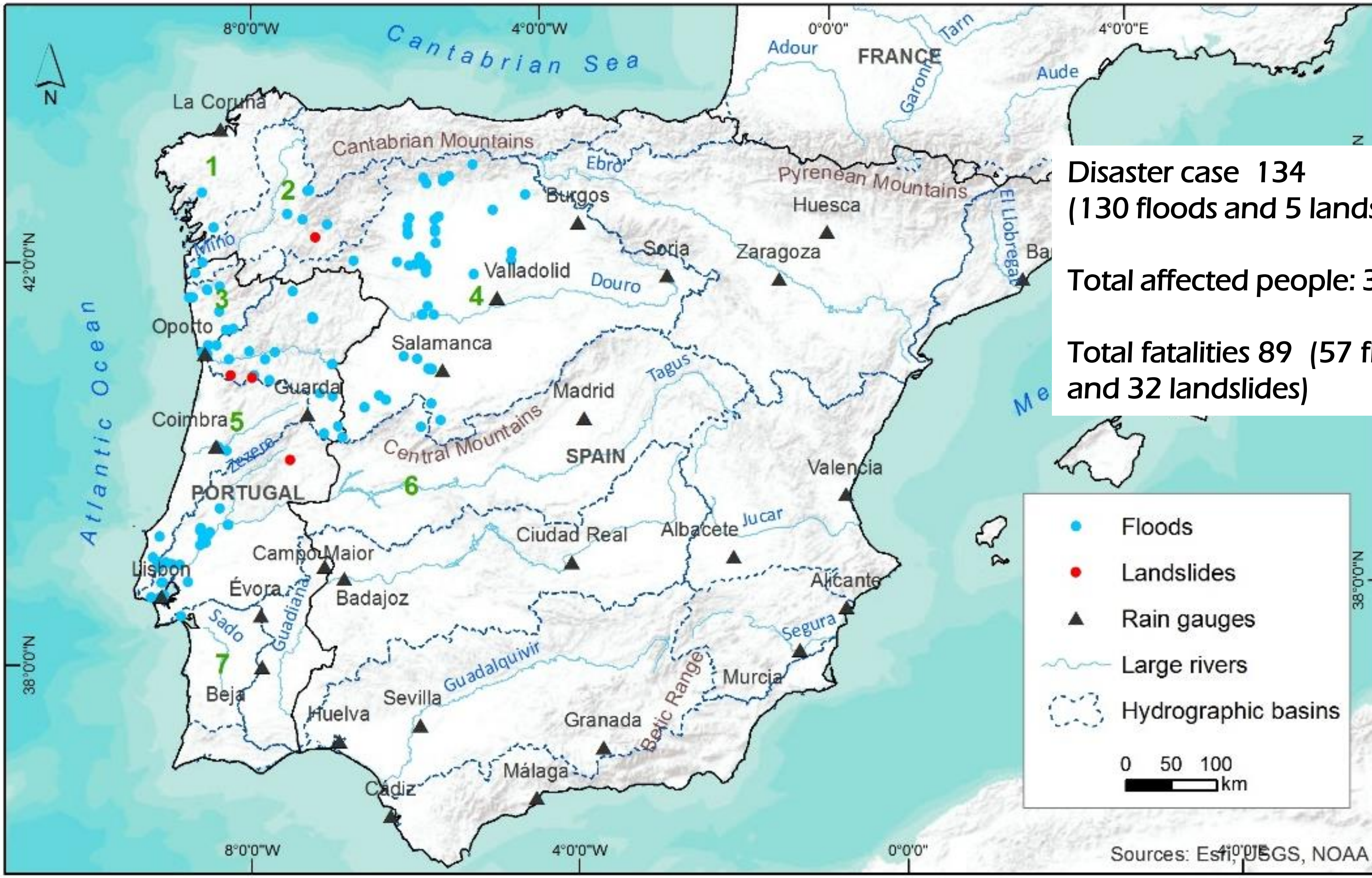
Largest floods in 200 years in Douro



Disaster case 134
(130 floods and 5 landslides

Total affected people: 3876

Total fatalities 89 (57 floods and 32 landslides)

Flood and landslide DISASTER cases from 20–28 December 1909 event over Iberia.

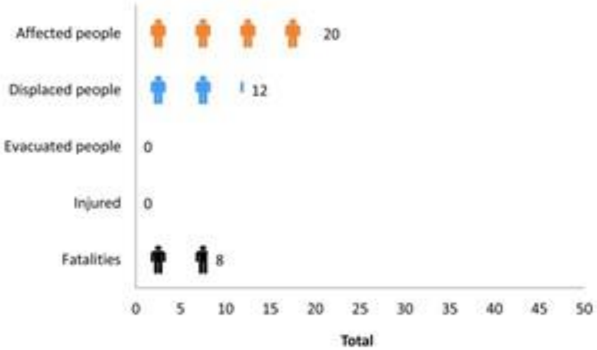
Source: Disaster database for Portugal and Spanish newspapers.

Numbers in the map correspond to the affected hydrographic basins: (1) Coruña basins;(2) Minho Basin; (3) Lima and Cávado basins; (4) Douro Basin; (5) Águeda, Mondego, and West basins; (6) Tagus Basin; (7) Sado Basin.

FORLAND Catalogue

7 - 9 December 1876

Human Damages



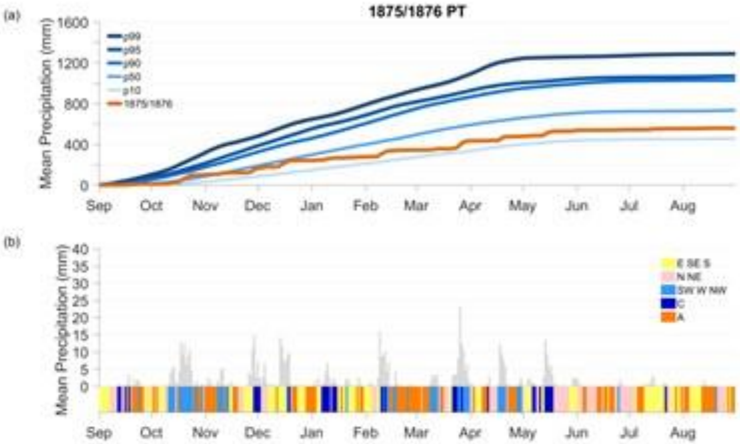
Spatial distribution

10 Disaster Cases
10 Floods
0 Landslides

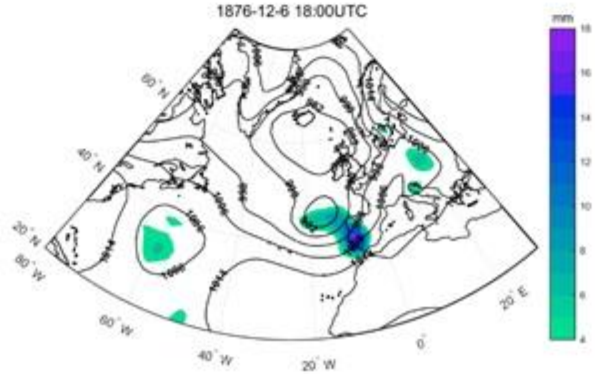
Rainfall Percentil:
At 7 Dec. 99th
At 9 Dec. 99th

Dominant CWT:
W and NE

Antecedent rainfall conditions



Atmospheric circulation



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EARTH SCIENCE
ORIGINAL RESEARCH ARTICLE
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The record precipitation and flood event in Iberia in December 1876: description and synoptic analysis

Ricardo M. Trigo[1]*, Filipa Varino[1], Alexandre M. Ramos[1], Maria A. Valente[1], José L. Zêzere[2], José M. Vaquero[3], Célia M. Gouveia[1] and Ana Russo[1]

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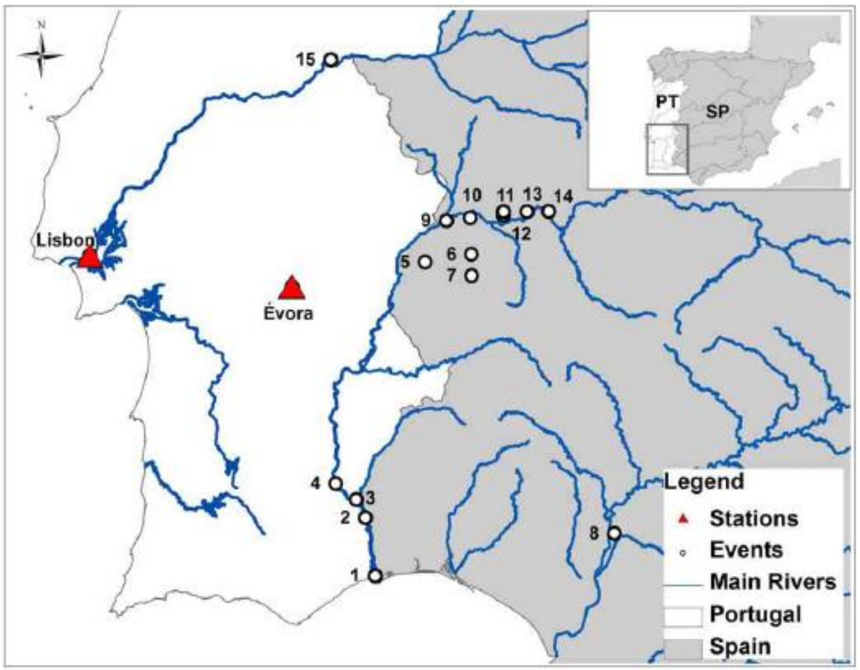
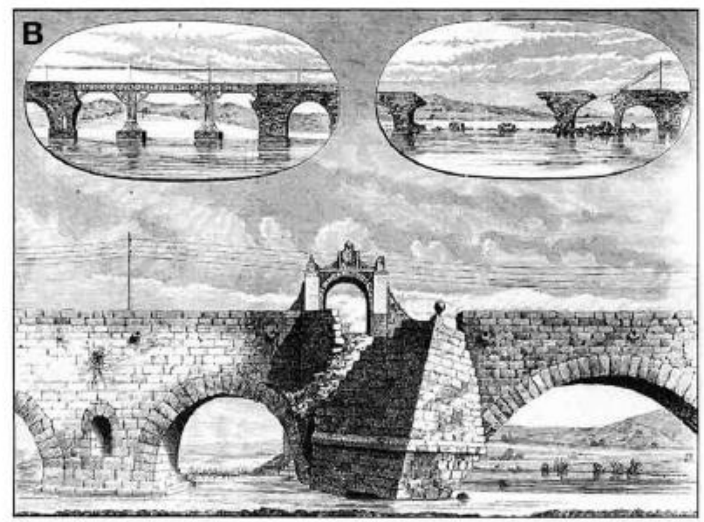


FIGURE 2 | Location of some of the most affected places by the flood of 1876 mentioned by several newspapers. 1- Vila Real de St António, 2- Alcoutim, 3- Pomerão, 4-Mértola, 5-Olivenza, 6-La Albuera, 7- Almendral, 8- Seville, 9- Badajoz, 10- Talavera la Real, 11- Puebla de la Calzada, 12- Montijo, 13- Gévora, 14- Mérida, 15- Vila Velha de Rodão.



Damages in the great Roman Bridge in the city of Mérida caused by the rising of Guadiana river.

4. CONCLUSIONS

- The typology and severity of impacts from climate extreme events depend not only on the extremes themselves and on the physical constrains of the landscape, but also on exposure and vulnerability of societal system.

- The disaster events catalogue is an important historical and meteorological data source of the damaging floods and landslides that occurred in Portugal in a 150-year period.

- This catalogue allows for the ranking of disaster events in the country in terms of human damages and the type of meteorological system that triggered the events.

- The catalogue is used to identify those events that generated higher impacts in populations and settlements along time and space, contributing to the further detailed study of the events at national and Iberian scale, and to the civil protection authorities to associate the predicted CWT with the generation of specific hydro-geomorphological events and associated types of damage.

- The methodology used to build the DISASTER database and the disaster events catalogue can be applicable to other study areas where floods and landslides are mostly associated with the atmospheric circulation, as is the case of the North Atlantic and the Mediterranean regions.

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IGOT Instituto de Geografia e Ordenamento do Território UNIVERSIDADE DE LISBOA

CEG Centro de Estudos Geográficos

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Thank you for your attention!

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A centennial catalogue of hydro-geomorphological events and their atmospheric forcing

Check for updates

Pereira S.[a,*], Ramos A.M.[b], Rebelo L.[b], Trigo R.M.[b], Zêzere J.L.[a]